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[54] Title of Invention: POLYESTER FIBERS FOR NON-WOVEN FABRICS AND PROCESS FOR MANUFACTURE THEREOF

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[72] Inventors:
K. Hirose, 43-8 Azakui-ana, Nishiohtomocho, Okazaki City
R. Kinoshita, 32-2 Asakura, Tomogoecho, Okazaki City
T. Kume, 1 Kamikawanari, Tomogoecho, Okazaki City
T. Sato, 188 Aza-Jinba, Hanemachi, Okazaki City
F. Kobayashi, 4-1 Hinakitacho, Okazaki City

[71] Applicant: Nippon Ester KK (Japan Ester Company Ltd.), 4-1 Hinakitacho, Okazaki City

[74] Agent: Patent Attorney Y. Kodama

SPECIFICATION

(1) Title of Invention

Polyester fibers for non-woven fabrics and a process for manufacture thereof.

2. Claims

(1) A polyester fiber for non-woven fabrics comprising a crimped side-by-side conjugated fiber of 2 polyesters with different inherent viscosities, wherein said fiber has a denier of 3 denier or less, a crimped resiliency of at least 85%, a percentage free length* {* Translator's note: This term is defined later in text.} of not more than 70%, and a percentage crimping after heat treatment for 15 minutes at 130°C of at least 90% relative to that before the treatment.

(2) A polyester fiber as set forth in Claim 1 wherein the surface thereof is treated with a silicone treatment agent.

(3) A process for the manufacture of a polyester fiber for non-woven fabrics which comprises drawing an undrawn yarn at a draw ratio of 85-95% of the maximum draw ratio thereof, and carrying out a relaxation-heat treatment, said yarn being prepared by conjugating side-by-side polyesters of 2 different inherent viscosities under conditions such that the relationship below is established with respect to the difference in inherent viscosity of the 2 polyesters, $\Delta\eta$, the spinneret orifice diameter d(mm), and the product monofilament denier, D (denier), producing an undrawn filament yarn and drawing the yarn:

$$\Delta\eta \geqq \frac{1}{60}(D-1) \quad \cdots\cdots (1)$$

$$d \geqq (7.2D+21.6)\Delta\eta^2 - 0.24(D+1)(D+3)\Delta\eta + 20\times10^{-4}(D^3+5D^2+32D+78) \quad \cdots\cdots (2)$$

$$d \leqq 0.2(D+1) \quad \cdots\cdots (3)$$

3. Detailed Description of the Invention

The present invention is a novel fiber comprising polyester fibers having a denier of 3 denier or less, having high crimpability, and capable of providing a good non-woven fabric, and a process for the manufacture thereof.

Because of their excellent heat stability, dimensional stability, washability, economic advantages and the like, polyester fibers have been used in a broad range of applications, recently being frequently used in fields such as outer wear which requires a warmth retention effect as represented by fiberfill in quilting material. These applications normally involve using

polyester fibers in non-woven fabrics which characteristically must have many pores therein, and have a high warmth retention [insulation] effect; for this use, the non-woven fabrics must be bulky. Secondly, the configuration of non-woven fabrics must not be lost while they are processed or worn. Typical examples of the above loss of configuration include a loss of bulk when subjected to repeated compression, the so-called "set" or an unrecovered elongation when subjected to repeated extensions and contractions, or a scission. The third requirement is that the fabric drape well.

The treatments often provided in accommodating the above requirements include firstly, the use of a so-called fiberfill polyester fiber having a denier which is normally at least 6 denier, which is provided with bulkiness resulting from the action of the crimps; secondly, use is made of a non-woven fabric by adhering the component fibers to themselves with a synthetic resin binder or the like. However, non-woven fabrics prepared by these procedures are made up of component fibers having a large denier, ending up with high rigidity and a stiff hand rendering them unsuitable for outer wear quilting fiberfill that requires a soft hand and drapability.

As a result of studies by the present inventors on a variety of fibers, in order to overcome these deficiencies, they have come to invent a polyester fiber capable of providing a non-woven fabric suitable for a soft-hand, tough, and highly stretchable outer wear quilting fiberfill.

That is, Invention 1 of the invention is a polyester fiber for non-woven fabrics comprising a crimped side-by-side conjugated fiber of 2 polyesters with different inherent viscosities, wherein said fiber has a denier of 3 denier or less, a crimped resiliency of at least 85%, a percentage free length of not more than 70%, and a percentage crimping after heat treatment for 15 minutes at 130°C of at least 90% relative to that before the treatment.

Invention 2 is a process for the manufacture of a polyester fiber for non-woven fabrics which comprises drawing an undrawn yarn at a draw ratio, 85-95% of the maximum draw ratio thereof, and carrying out a relaxation-heat treatment, said yarn being prepared by conjugating side-by-side polyesters of 2 different inherent viscosities under conditions such that the relationship below is established with respect to the difference in inherent viscosity of the 2 polyesters, $\Delta\eta$, the spinneret orifice diameter d(mm), and the product monofilament denier, D (denier), producing an undrawn filament yarn, and drawing the yarn:

$$\Delta\eta \geq \frac{1}{60}(D-1) \cdots\cdots \text{(1)}$$

$$d \geq (7.2D+21.6)\Delta\eta^{2} - 0.24(D+1)(D+3)\Delta\eta$$
$$+ 20\times10^{-4}(D^{3}+5D^{2}+32D+78) \cdots\cdots \text{(2)}$$

$$d \leq 0.2(D+1) \cdots\cdots \text{(3)}$$

Non-woven fabrics are commonly prepared by carding the original fiber material into a web, spraying it, depending up applications, with an emulsion binder such as a polyacrylate ester for a single sheet of web, or generating a product by laying down several sheets of web for applications, heat treating, thereby adhering the fibers to themselves. Another example calls for blending in a thermally fusible polymer binder-fiber as raw fiber material, followed by uniformly mixing by a card, thereby generating a web and shaping by thermally fusing the fibers to themselves by a means similar to the above.

The present invention provides for a fiber suitable for non-woven fabrics by such common, frequently used, non-woven fabric shaping processes. In other words, it is an object of this invention to provide a polyester fiber capable of producing a non-woven fabric which is highly bulky, drapable, durable against repeated stretchings and contractions; such fibers are required to be provided with the properties given below at the same time: There have been fibers which met 1 or 2 of the properties in the past, but there have been none which possessed all of the properties at the same time.

First, the fiber of this invention must have a percentage free length of not more than 70%. The "percentage free length" referred to by this invention is a numerical value which expresses the extent of the fiber's bending by percentage ($l_1/l_0 \times 100$), as illustrated by (a)-(d) of Figure 1, where l_1 is measured as a staple fiber sample is freely laid on a smooth plate as the greatest length of said fiber and l_0 is the fiber's length as defined in the JIS 1074-1977, 6 4.1C procedure. The smaller the percentage of free length, the greater the bulk of each fiber in a given non-woven fabric; it will be sufficient for the fiber to have a percentage free length, as measured by the method given above, of not more than 70%, because in the non-woven fabric made of fibers through a card machine, the fibers receive directional properties.

Secondly, the fiber of this invention must have a crimp resiliency of at least 85%. A non-woven fabric for outer wear, unlike fiberfill for bedding comforters or cushions, must have excellent extension recovery, not only recovery from compression, because the fabric is subjected to flexing or stretching according to the movement of the body, with a repeated substantial deformation in the elbow and knee portions. The fibers themselves are ideally point-to-point adhered by the binder so that the entire non-woven fabric is secure with respect to retention of configuration, but its recovery will become poorer against deformation if the fiber itself has low elasticity. In

the case of polyester fibers, fiber elasticity is represented by its crimp elasticity so that in order for such a non-woven fabric to be durable against the usual usage, the constituting fiber must have a crimp resiliency of at least 85%.

Third, the fiber of this invention must have a denier of 3 denier or less. According to many trials by the present inventors, for use as a quilting fiberfill on outer wear, the bending rigidity of the fiber must be sufficiently low in order for it to have sufficient warmth retention strength and to be drapable, and further to be sufficiently flexible, even when treated with an emulsion binder or thermal fusion type binder. Therefore, it is preferred for the fiber denier to be small, in general, 3 denier or less for conventional applications.

Fourth, an important condition for the polyester fiber of this invention is to have 90% or better retention of percentage crimping after a 15 minute heat treatment at 150°C (JIS 1074-1977 6.11 Section) with respect to the retention before treatment. As discussed above, the quilting fiberfill is commonly treated with an emulsion binder or thermal treatment type binder so as to mutually adhere the fibers; in every case, the fiber is heat treated by a hot air treatment machine to a temperature of 130°C or higher. When the fiber is extended by such a treatment, the product will have a considerably poor hand as a non-woven fabric so that the percentage crimp retention upon heat treatment for 15 minutes at 130°C must be held at 90% or higher with respect to that of before treatment, .

Such polyester fibers can be obtained at the time of melt spinning, using polyesters of 2 suitably different inherent viscosities, thereby generating a side-by-side conjugate fiber, followed by drawing and carrying out a relaxation heat treatment.

Treating the fiber surface with a silicone treatment agent makes the fiber smooth and also adds flexibility, thereby giving an effect of providing an excellent hand, which is preferred.

An example of the treatment of the fiber surface with a silicone treatment agent includes a method of imparting to a drawn fiber tow a dispersion in water of dimethyl polysiloxane (70 parts by weight) and an amino silane compound (25 parts by weight), along with a metal salt catalyst (5 parts by weight), followed by diluting to a 2% concentration, to the extent of 10%, by spraying with respect to the fiber, followed by heat treating for 5 minutes at 170°C and cutting to give a staple.

The above polyester fiber can be prepared by the following methods: In order to give a sufficient crimp formation capability with a side-by-side

conjugate fiber, the difference in inherent viscosity of the 2 polymers should preferably be as large as possible, as is known in the art.

Too large a difference a viscosity will cause "kneeing" immediately below the spinneret at the time of melt-spinning, with a considerable increase in the breakage of the spun yarn. In order to prevent the kneeing, it is effective to have a large spinneret diameter; too large a spinneret diameter will result in a breakage on drafting, with the generation of yarn breakage, making spinning impossible.

The present inventors, from many trials, discovered that the melt-spinning of the polyester fibers of this invention must satisfy each of the following relationships among the inherent viscosity difference $\Delta\eta$ between the 2 polymers, spinneret orifice diameter d(mm), and product monofilament denier D (denier):

$$\Delta\eta \geqq \frac{1}{60}(D-1) \quad \cdots\cdots (1)$$

$$d \geqq (7.2D + 21.6)\Delta\eta^{2} - 0.24(D+1)(D+3)\Delta\eta + 20\times10^{-4}(D^{3}+5D^{2}+32D+78) \quad \cdots\cdots (2)$$

$$d \leqq 0.2(D+1) \quad \cdots\cdots (3)$$

Hereafter, reasons for meeting the relationships of each equation are described.

First, in order to obtain the crimped formation capability which is necessary for the polyester fiber of this invention, the difference in inherent viscosity of the 2 polyesters must be sufficiently large, according to the relationship of equation 1 as a function of product monofilament denier. In Figure 2, this corresponds to the region to the right of the line a - b. In order to permit good spinning while preventing kneeing, the spinneret orifice diameter, within the bounds of the relationship between the difference in inherent viscosity and product monofilament denier, must meet equation 2; that is, it must fall in the region above curve bc in Figure 2. In order for the drafting-breakage to be prevented, equation 3 must be met, that is, the operation must be in the region below line ca in Figure 2.

The resultant undrawn yarn is then drawn by a conventionally known drawing method where the drawing must be carried out at a draw ratio, 85-95% of the maximum draw ratio. This is so that the latent crimp capability imparted during the above melt-spinning is fully developed.

The term maximum draw ratio is a draw ratio at which the monofilament breakage begins to occur at the most suitably selected draw temperature.

After drawing, the crimp formation treatment is carried out by a relaxation heat treatment where one may carry out the relaxation heat

treatment after providing the fiber with crimps using a stuffing crimper, with essentially no delay.

Use of the fibers of this invention permits production by the usual method of a non-woven fabric which is bulkier and drapable, more so than previously available, and is rich in stretchability, suitable in quilting fiberfill for outer wear.

The present invention is now described in detail by Examples of this invention, which however, will not limit the scope of this invention.

Example 1

5 polyethylene terephthalates were obtained by polymerization using the conventional process so as to encompass inherent viscosities of 0.69, 0.65, 0.62, 0.55, and 0.52, from which combinations of 2 polymers were selected to carry out spinning using a side-by-side conjugate spinning device at a spin temperature 280°C under the rest of the conditions as given in Table 1.

The undrawn yarns a and b obtained were bundled to a 100,000 denier size on which the maximum draw ratio was measured so as to permit drawing at a ratio 90% of that value, at a draw speed of 120m/min and at a draw temperature 70°C, followed by a relaxation heat treatment for 5 minutes in a heat treatment device at 150°C to give products having physical properties as given as (g) and (h).

The undrawn yarns (a) and (b) obtained in Example 1 were bundled to a 100,000 denier size on which the maximum draw ratio was obtained using the drawing machine used in Example 1 to give data (i),(j),(k) of Table 3, followed by drawing at draw ratios according to the Table and by a relaxation heat treatment for 5 minutes at 150°C, under conditions otherwise similar to those of Example 1. The resultant products had the physical properties in Table 3 (i),(j),(k), none of which were satisfactory.

Table 1

Symbols	Examples and Comp. Examples	Goal Denier	Polymer Inherent Viscosity	Spinneret Orifice Diameter (mm)	Rate of Extrusion per Orifice (g/min)	Spinning Speed (m/min)	Note
a	Ex	3	0.69/0.55	0.55	1.06	1100	Spun Well
b	Ex	2	0.69/0.62	0.4	0.70	1200	Spun Well

c	Comp.Ex	3	0.69/0.52	0.55	1.06	1100	Much Kneeing Frequent Breakage
d	Comp.Ex	3	0.65/0.62	0.55	1.06	1100	Spun Well
e	Comp.Ex	2	0.69/0.62	0.65	0.70	1200	Frequent Breakages
f	Comp.Ex	2	0.62/0.55	0.20	0.70	1200	Extensive Kneeing Frequent Breakage

Table 2

Symbol	Examples Comp. Examples	Maximum Draw Ratio	Draw Ratio (%)	Final Product			Note
				Denier (Den)	Crimp Resilience (%)	Percentage Free Length(%)	
g	Ex	4.15	90	3.0	90	46	
h	Ex	5.70	90	2.1	88	50	

* Draw ratio percent = $\dfrac{\text{draw ratio}}{\text{maximum draw ratio}} \times 100$

Table 3

Symbol	Example Comp. Examples	The Undrawn Yarn Used	Maximum Draw Ratio (%)	Draw Ratio (%)	Final Product			Note
					Denier (Den)	Crimp Resilience (%)	Percentage Free Length(%) (%)	
i	The Comp. Examples	a	4.15	94	2.9	94	40	Poor stretch operation
j	Ditto	a	4.15	83	3.3	82	62	
k	Ditto	d	4.19	90	3.0	80	71	

* The draw ratio was calculated as given in Table 2.

Example II

Staples (g) and (h) obtained in Example I, 80% by weight, were each uniformly mixed with 20% by weight of a polyester based binder fiber having a

melting point of 130°C (a product by Unitika Company "Melty" [transliterated.] 4^d x 51mm), and carded to prepare a web with a unit weight of $120g/m^2$. The resultant web was heat treated for 30 minutes in a heating oven controlled at 130°C to carry out a heat treatment for 3 minutes, thereby melting the binder fiber to obtain non-woven fabrics (l),(m)

Comparative examples were prepared using 6^d x 51mm polyester hollow conjugate fiberfill, conventional polyester fiberfill 3^d x 51mm, and 2^d x 51mm shown in Table 4 to carry out the same treatment as above to obtain non-woven fabrics (n),(o),and (p). The resultant non-woven fabrics were subjected to measurement by a cantilever method (JIS L-1096 6.19.1 Method A) for rigidity and specific volume.

The staple samples used for shaping the above non-wove fabrics were separately heat treated for 15 minutes in an atmosphere at 130°C where the percent crimp before and after heat treatment was measured, as shown in Table 6. It is clear that the non-woven fabrics from fibers of this invention have high specific volumes and exhibit excellent drapability.

Table 4

Fiber Types	Denier (Den) x Fiber Length (mm)	Result Elasticity (%)	Percentage Free Length(%)	Note
Polyester Hollow Conjugate Fiber-fill	6 x 51	92	45	
Polyester Regular Fiberfill	3 x 51	75	59	
Ditto	2 x 51	73	61	

Table 5

Examples	Unit Weight (g/m^2)	Specific Volume (m^3/g)	Rigidity (cm)	Note
Example (l)	120	96	9	
Ditto (m)	118	92	9	
Comp. Examples (n)	118	105	17	
Ditto (o)	123	70	16	
Ditto (p)	121	65	14	

Table 6

	Percent Crimping (%)

	Before Heat Treatment	After Heat Treatment
Examples (l)	16	17
Ditto (m)	114	14
Comp. Examples (n)	23	22
Ditto (o)	14	5
Ditto (p)	13	5

4. Brief Description of the Drawings

Figure 1 is a schematic diagram illustrating the staple fibers; Figure 2 is a graph showing the relationship between the polymer inherent viscosity difference Δη and spinneret orifice diameter d.

Fig. 1

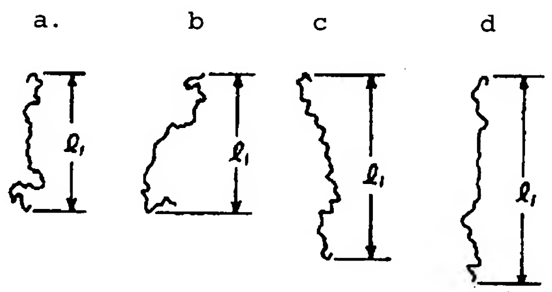
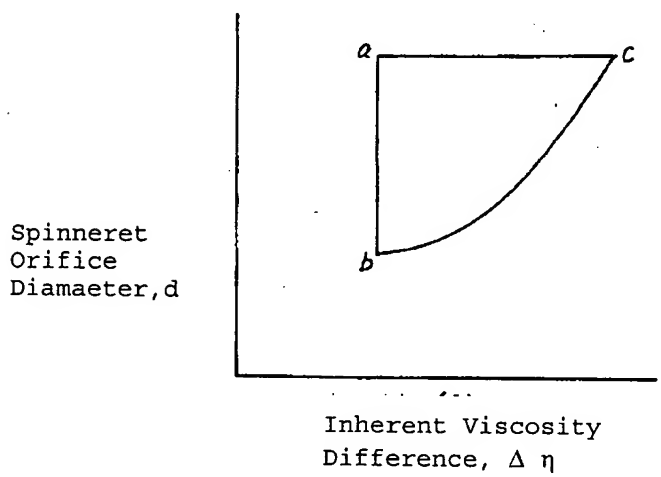


Fig. 2



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